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# IGY BULLETIN

*A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.*

## Status of Geomagnetism Program

*The following material is based primarily on a report to the US National Committee for the IGY by Elliot B. Roberts, Chief, Division of Geophysics, US Coast and Geodetic Survey, and Vice-Chairman, USNC-IGY Technical Panel on Geomagnetism.*

The major portion of the earth's magnetic field is thought to be generated by electric currents within the earth. The remaining portion, about 5% of the field, is generated externally, it is believed, by great, globe-girdling systems of electric currents in the charged, or ionized, regions of the upper atmosphere. The earth-generated part of the field is relatively stable, undergoing slow, "secular" changes measured in years, tens of years, or even centuries. The externally-generated part of the field is characterized by rapid, or transient, fluctuations measured in days, hours, minutes, and seconds. It is with these transient fluctuations that the IGY Geomagnetic Program is mainly concerned.

Daily variations in the magnetic field are believed to be tidal (solar and lunar) in origin. Other rapid fluctuations and disturbances may result from the entry into the earth's upper atmosphere of (1) energetic ionizing radiations, and (2) high-velocity, electrically-neutral streams of corpuscles. Both the radiations and the corpuscles originate in explosive activity on the sun.

The magnetic-field vector (magnitude and direction) at any point is measured in terms of various elements or components. These include the magnetic intensity in the vertical and horizontal planes, dip (inclination of the magnetic vector with respect to the horizontal), and declination (the angle between the magnetic vector and the geographic meridian).

Continuous recording of the magnetic field components is accomplished with instruments called magnetometers or magnetographs. Absolute calibration must be applied to these instruments periodically with specially-designed magnetometers. At stations where observations are made over many years, permitting study of the secular changes, observatory-type instruments are employed. These are magnetometers characterized by low, uniform base-line drift and stable response. At stations established for short periods, where recording of magnetic-field variations and storm responses is of major interest, small portable magnetometers called variometers or variographs are used. Absolute calibrations are also applied to variometers, but in general the records are more useful for study of transient rather than secular changes.

The several components of the magnetic field have for years been measured and recorded by instruments installed at magnetic observatories in many parts of the world. These have helped form a picture of the overall magnetic field. During the IGY,

however, networks of stations have been established in regions of special interest. Examination of the differences between records obtained at the stations reveals information on the behavior, location, and extent of the electric currents circulating in the upper atmosphere.

The objective of the geomagnetism program, broadly speaking, is to record synoptically the variations in the earth's magnetic field. The frequency band primarily under study ranges from about 50 cycles/sec to one cycle/yr. Geographic areas of greatest interest are the polar regions, including the auroral zones, and the rather narrow band along the magnetic equator. Figure 1 shows the locations of IGY geomagnetic stations in equatorial and middle latitudes as well as some in high latitudes (see *Bulletin No. 3* for map showing all polar stations).

**Polar Regions**

Records obtained at the magnetic observatories at the Little America, Byrd, Wilkes, and South Pole IGY Stations, Antarctica, furnish material for the study of magnetic storm conditions as a world-wide phenomenon—allowing comparison with records obtained in the equatorial and north polar regions.

The variometer on IGY Drifting Station A, in the Arctic Ocean ice pack about 300 mi from the North Pole, supplies information on general magnetic activity well within the auroral zone. Rotation, tilt, and drift of the station make necessary elaborate computations to reduce the records to standard components. Therefore, no routine reductions are contemplated.

**Continental US**

Records received from the east-west network of variometer stations in the United States are available for study of the effects of mass-transport of ionized gases or of other meteorological relations. At present, processing of the records consists only of tabulating mean hourly values.

**South American Network**

Near the magnetic equator, the daily variation in the horizontal component of the earth's magnetic field is unusually large. This abnormality is exceptionally well exhibited at Huancayo, Peru, where a permanent magnetic observatory is located very close to the magnetic equator.

In 1949, observations were made at fourteen locations along the west coast of South America, from geographic latitude 3.4° N to 16.2° S, to study this variation. These observations showed a steep decrease in the amplitude of the daily fluctuations of the horizontal component with distance north and south of the equator. This indicated the existence of a narrow band of concentrated electric current flowing eastward in the upper atmosphere during midday. This current—the equatorial "electrojet"—is superposed on the more diffuse current distribution that accounts for the normal, quiet-day magnetic variations.

To determine whether magnetic field variations other than the daily variation also show electrojet effects, four stations equipped with Askania variographs were established for the IGY on the west coast of Peru by the Department of Terrestrial Magnetism, Carnegie Institution of Washington, in cooperation with the Instituto Geofisico de Huancayo. They are located at Talara, Chiclayo, Chimbote, and Yauca, ranging from geographic latitude 4° N to 15° S. Magnetographs at the Instituto Geofisico de Huancayo (12° S) provide data at a fifth location and a magnetograph recently installed at the University of Arequipa (17° S) will provide data at a sixth.

To locate the latitudinal limits of electrojet effects on the daily magnetic variation, and to determine strategic locations for the four Askania variograph stations mentioned above, records were obtained at 16 more-or-less uniformly spaced locations between the geographic equator and 22° S in the spring of 1957. Two or three complete daily records were secured at each station.

The maximum daily variation of the

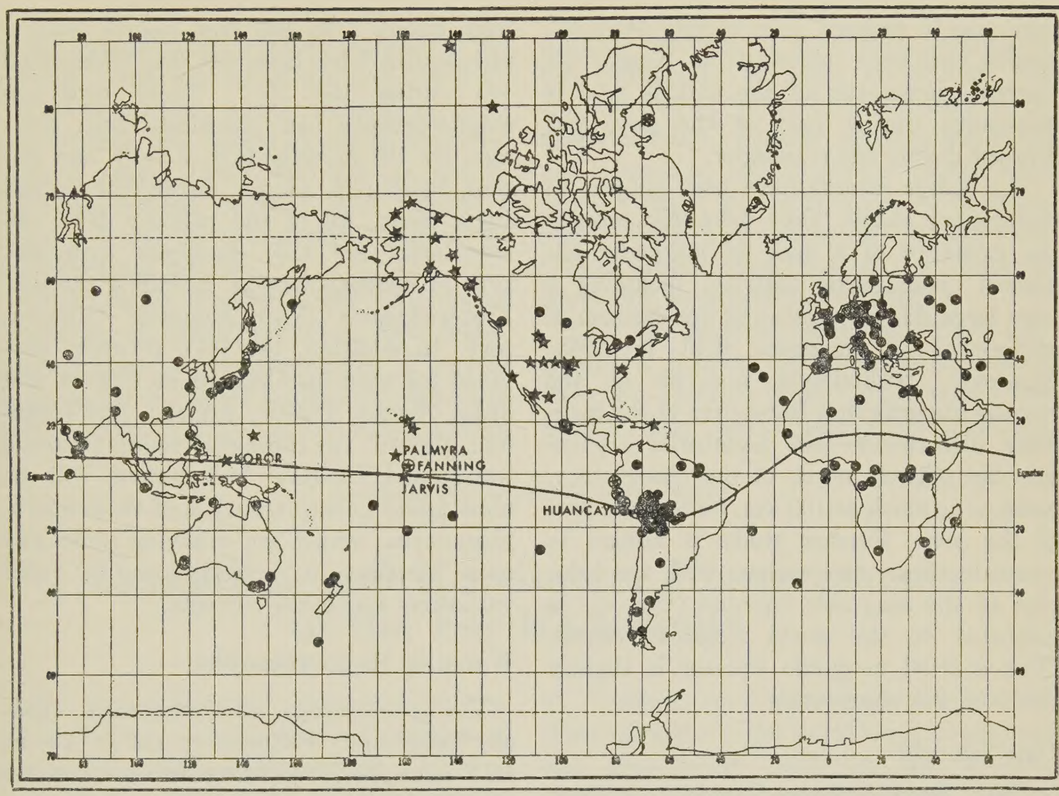


Fig. 1. *IGY Geomagnetic Stations. Stars: US Stations. Dots: Stations of other countries. Circled Stars: Cooperative Stations. Heavy solid line represents approximate position of magnetic equator.*

horizontal component was found to occur within 1° of latitude of Huancayo (12° S). This is in accord with results from the 1949 survey. It is also confirmed by the fact that the daily variation of the vertical component of the earth's magnetic field, obtained during the 1957 survey, changes sign at a latitude within 1° of Huancayo. A maximum daily variation in the vertical component occurred at about 16° S, and another maximum, with opposite sign, occurred near 8° or 9° S.

The north-south distance of 500 mi between these extremes provides a rough estimate of the width of the electrojet band. The difference with latitude of the daily variation of the vertical component indicates the importance of the return currents, which must flow westward, to the north and south of the eastward-flowing electrojet.

To estimate reliably the height and width of the electrojet, the electric current system of the electrojet field must first be derived. Before this derivation can be accomplished, the normal, quiet-day solar variation, estimated from data obtained at locations free from the influence of the electrojet, must be subtracted. Such height and width estimates have not yet been completed.

A preliminary examination of records indicates that many of the vertical-component fluctuations related to solar disturbances are greatest at the same latitudes where the largest quiet-day solar tidal variation in this component was observed. The sign of the fluctuations is opposite at these two latitudes, indicating electrojet effects.

**Pacific**

The site for the Koror Observatory, in the Palau Islands, was chosen with the intention of establishing a recording station as near as possible to the magnetic equator. Not until the observatory was actually in opera-

tion was it realized how closely that objective had been achieved: at Koror, the vertical component of the earth's field is downward during part of the day, and upward during the remainder.

The Koror records have been subject to preliminary study. They definitely support the existence of a zone of markedly enhanced geomagnetic activity, including a very large daily variation of the horizontal component of magnetic field intensity. Moreover, preliminary analysis of the records suggests that the source of the magnetic disturbance—the equatorial electrojet—lies slightly north of the observatory, perhaps as much as 100 km, for at least part of the year. Further study is needed to correlate these observations with the location of the magnetic equator (Fig. 1), as indicated on the world magnetic charts. (The charted magnetic equator is slightly south of the observatory.)

**Line Islands**

The Jarvis-Palmyra-Fanning project, operated by Scripps Institution of Oceanography with instruments supplied by the US Coast and Geodetic Survey, began operation very shortly after the formal commencement of the IGY.

Records from the three stations were shipped to the C&GS late in May 1958 for delivery to World Data Center A. Although there has been no opportunity to examine them critically, a preliminary inspection shows that the records tend to support observations made elsewhere of a concentration of electrojet effects in the vicinity of the magnetic equator. Such effects are indicated by the increased daily variation and by disturbance effects evident in the Jarvis records as compared with those from the more distant members of the group.

**Rapid-Run Records**

A type of instrumentation badly needed at US Magnetic Observatories for many years—instrumentation for recording rapid fluctuations of the earth's field in the range from about 4 to 100 secs (called "microphenomena") has been put into widespread use during the IGY. These rapid-run magnetographs had previously been operated by US investigators at only one station, Fairbanks, Alaska, during the Second Polar Year. All of the primary IGY observatories are now equipped with this type of instrumentation, including the new Fredericksburg (Va.) Magnetic Observatory. In addition, the IGY program provided for such installations at Barrow and Sitka, Alaska, Tucson, Arizona, and Honolulu, Hawaii. The rapid-run records from the widespread US-IGY installations will be most useful in future studies of these microphenomena, which are receiving more and more emphasis in investigations of rapid variations and earth currents.

**Warning Magnetographs**

Visible-recording, one-component (usually horizontal) variometers are in use at IGY ionospheric recording stations to assist in correlating ionospheric observations with the general level of magnetic activity. The records will not be systematically archived in the World Data Center.

**Sub-Audio Project**

The sub-audio frequency project was set up to provide a description, using magnetic tape recordings, of geomagnetic fluctuations in the frequency range of 1 to 50 cycles/sec.

The program involves investigation of the nature of sub-audio frequency signals which precede magnetic disturbances in the auroral zone by about a day. These signals may be confused with fluctuations originating in thunderstorm activity at lower latitudes. Hence, careful analysis is necessary. The most conclusive evidence will come from statistical analysis of the signal level as a function of frequency and time. Differences in signal levels between the vertical and horizontal components of the earth's field will also aid in this differentiation. Preliminary examination of the visual record

of the overall signal level, at the time of recording, tends to confirm previous findings.

The records also appear to confirm previous reports that signal levels in this frequency range, when recorded at appropriately situated stations, can furnish a running index of the world-wide level of thunderstorm activity.

Observations of some of the wave forms of the signals show interesting phenomena. Among these is the appearance of oscillations or regular micro-pulsations. Signals of varying frequency also occur. Some of them at first decrease in frequency, resembling the "whistlers" of audio frequencies (see *Bulletin No. 6*). Then, however, they sometimes increase; whistler propagation could not account for this. Analysis of these wave forms—which, at such frequencies, probably result from hydromagnetic phenomena—should provide new data on the sub-audio frequency geomagnetic fluctuations.

Five field stations participate in the program—at Ramey Air Force Base, Puerto Rico; Ft. Devens, Mass.; Mt. Evans, Colorado; College, Alaska; and Thule, Greenland.

# Pendulum and Gravimeter Measurements of the Earth's Gravity

*This report is based upon material furnished by George P. Woollard, Department of Geology, University of Wisconsin.*

The mass of the earth exerts an attractive force—gravity—on all bodies on the earth. However, because the earth is not a perfect sphere, because its mass is not uniformly distributed, and because the centrifugal force resulting from its rotation varies with latitude, gravity is not the same all over the earth. Measurement of the differences in gravity from place to place therefore reveals much information about the physical characteristics of the earth. Such measurements are especially important in studies of the true shape of the earth and the thickness and mass of its crust; in location of underground ore bodies and undersea mountains; and in accurately determining elevations and distances on the earth's surface.

The major aims of the IGY Gravity Program are to expand existing gravity networks in an effort to achieve as complete global coverage as possible, and to increase the reliability of gravity measurements. In the US program, scientists of the University of Wisconsin, under the direction of George P. Woollard, are making gravity determinations throughout the world using pendulums and gravimeters. Although less sensitive than gravimeters, pendulums can measure reliably changes in the gravity field of the earth. Hence, they are being used to establish a number of accurate key points to serve as linkages between the gravity networks of many countries and as a standard for calibrating the more sensitive gravimeters. Similar key points which existed prior to the IGY are being recalibrated. Within this framework, gravimeters are able to make highly sensitive measurements of the variations in gravity from one point to another.

## A. PENDULUM PROGRAM

The IGY pendulum program is a continuation of one that has been under way at the University of Wisconsin since 1951. Early measurements revealed systematic and random errors in accepted gravity base values. These errors were too large to permit effective integration of the world's gravity data into a unified whole having an overall accuracy approaching the desired value of 1 milligal. (One milligal, or mgal,

Table 1. *Comparison of Gulf and Cambridge Pendulum Values in North America*

| Location | Cambridge | Gulf | Difference |
|---|---|---|---|
| Fairbanks, Alaska | 982.2477 | .2455 | −2.2 |
| Whitehorse, Y. T. | 981.4073 | .7487 | −1.6 |
| Fort St. John, B. C. | 981.4073 | .4054 | −1.9 |
| Grand Prairie, Alb. | 981.3195 | .3176 | −1.9 |
| Edmonton, Alb. | 981.1691 | .1681 | −1.0 |
| Red Deer, Alb. | 980.9988 | .9970 | −1.8 |
| Lethbridge, Alb. | 980.7612 | .7590 | −2.2 |
| Ottawa, Ont. | 980.6220 | .6206 | −1.4 |
| Huron, S. D. | 980.4555 | .4535 | −2.0 |
| Madison, Wis. | 980.3696 | .3688 | −0.8 |
| Washington, D. C. | 980.1193 | .1192 | −0.1 |
| Beloit, Kans. | 980.9990 | .9985 | −0.5 |
| Tulsa, Okla. | 979.7664 | .7665 | 0.1 |
| Houston, Texas | 979.2990 | .2983 | −0.7 |
| Monterrey, N. L. | 978.8055 | .8049 | −0.6 |
| Mexico City, D. F. | 977.9415 | .9419 | 0.4 |

equals $1/1000$ gal, which represents an acceleration of 1 cm/sec.$^2$) Actually, apparent errors of over 20 mgals were discovered. The Gulf compound quartz pendulum apparatus was chosen to establish a series of world standardization measurements as it appears to hold the greatest promise for obtaining accurate values of gravity throughout the world.

## Description of Apparatus

The Gulf pendulums are designed to minimize knife-edge wear effects at the point of suspension, and the pendulum case is ionized with a radioactive salt to dissipate electrostatic charges built up on the moving pendulums. The pendulums are operated at constant temperature and are kept sealed in a dry atmosphere. The use of two pendulums swinging 180° out of phase on a common support minimizes sway in the support. Timing is done with a crystal-regulated chronometer periodically checked against WWV radio time signals. Recording was first done photographically, but now the period is read directly from an electronic digital recorder.

## Observation Procedure

An observation consists of four independent pendulum measurements of one hour's duration each. The four measurements are made to eliminate errors that result because the pendulum knife edge is positioned slightly differently on the bearing flats during each measurement. When variations between independent swings are greater than ±0.2 mgal, observations are continued until four agree within this arbitrary limit. The mean value for all swings is adopted as the period for the site.

To guard against error, two precautions are now being taken that were not followed earlier. One is to repeat in reverse order any series of observations. For example, the series Panama, Quito, Lima, La Paz, Santiago would be repeated from Santiago back to Panama. The other is to use a geodetic gravimeter in conjunction with the pendulum observations. Thus, if there are any jumps owing to knife-edge wear, or to any other cause, there is a double check to indicate where and when trouble occurred and how much of an error was introduced. Since this procedure was adopted, with the beginning of the IGY program, there have been no problems concerning values. This does not apply to earlier measurements, some of which were doubtful and required repeat observations.

## Accuracy of Values

Studies involving three different sets of pendulums have been conducted, and while a single set of pendulums is inherently consistent to ±0.2 mgal, one set may differ from another by as much as 1.0 and occasionally 1.5 mgal on an interval measurement.

In addition, comparative measurements have been made against the magnetically compensated compound Invar pendulum of Cambridge University, England, and the magnetically compensated single Invar pendulum apparatus of the US Coast and Geodetic Survey. Such comparisons show no systematic differences; overall agreement within 1 mgal was obtained between Alaska and Mexico (see Table 1).

Another independent evaluation of the pendulum results is furnished by compara-

tive measurements with carefully calibrated, high-range, geodetic-type gravimeters having a reading accuracy of 0.1 mgal. Here, the average agreement is found to be about ±0.5 mgal (see Table 2).

On the basis of all of these comparative measurements, it appears that an accuracy of about 0.3 to 0.5 mgal is being obtained with the Gulf pendulums.

**Program of Observations**

Prior to the IGY, one series of pendulum measurements from Mexico City to Fairbanks, Alaska, had been completed, covering a range of approximately 4800 mgals. This series was adopted as a standard for determining the operating characteristics and calibration of high-range geodetic gravimeters used by the University of Wisconsin for global gravimeter measurements. To strengthen these standardization measurements, the Dominion Observatory of Canada, using the Cambridge pendulums, and the USC&GS reoccupied most of the University of Wisconsin sites. On the basis of the agreement obtained, it was decided to extend the pendulum program and establish another, comparable standardization range for other parts of the world. At the same time, this would serve as a control net of bases for integrating gravity data from all sources into a unified system. This second series of Gulf pendulum bases was established just prior to the IGY. It extends from Oslo, Norway, to Cape Town, South Africa. At most of the sites occupied, observations have also been made with the Cambridge pendulums.

A problem in gravity work is the use of several different gravity calibration standards in different parts of the world. These differ by as much as 12 mgals per 1000 mgals of change in gravity. As this situation leads to major discrepancies that would hamper attempts to integrate world data, it was decided that additional Gulf and Cambridge pendulum measurements were desirable. These were included in the IGY Program.

**Results**

The program to date has resulted in a new series of Gulf pendulum measurements which extends the North America standardization range northward to Pt. Barrow, Alaska, on the Arctic Ocean, and southward through Panama to Punta Arenas, Chile, at the southern tip of South America. Figure 2 shows the geographic distribution of Gulf pendulum sites. In the Pacific Ocean area, measurements have been established

Table 2. *Comparisons of Gravimeter and Gulf Pendulum Values in the United States*

| Location | Av. M-K Pendulum Value | Gravimeter Values | | Difference from Pendulum Values (mgals) | |
|---|---|---|---|---|---|
| | | W10F | 147 | W10F | 147 |
| Cutbank, Mont. | 980.6077 | 980.6084 | 980.6083 | +0.7 | +0.6 |
| Great Falls, Mont. | 980.5263 | 980.5269 | 980.5269 | +0.6 | +0.6 |
| Huron, S. D. | 980.4535 | 980.4533 | 980.4536 | −0.2 | +0.1 |
| Billings, Mont. | 980.3697 | 980.3704 | 980.3703 | +0.7 | +0.6 |
| Madison, Wisconsin | 980.3688 | 980.3689 | 980.3689 | +0.1 | +0.1 |
| Sheridan, Wyo. | 980.2254 | 980.2263 | 980.2265 | +0.9 | +1.1 |
| Washington, D. C. | 980.1007 | 980.1007 | 980.1007 | 0.0 | 0.0 |
| San Francisco, Cal. | 979.9863 | 979.9863 | 979.9864 | 0.0 | +0.1 |
| Casper, Wyo. | 979.9550 | 979.9560 | 979.9557 | +1.0 | +0.7 |
| Tulsa, Okla. | 979.7665 | 979.7662 | 979.7662 | −0.3 | −0.3 |
| Cheyenne, Wyo. | 979.6990 | 979.7004 | 979.7000 | +1.4 | +1.0 |
| Denver, Colo. | 979.6103 | 979.6106 | 979.6104 | +0.3 | +0.1 |
| Amarillo, Texas | 979.4243 | 979.4237 | 979.4233 | −0.6 | −1.0 |
| Houston, Texas | 979.2983 | 979.2984 | 979.2984 | +0.1 | +0.1 |
| San Antonio, Texas | 979.1966 | 979.1975 | 979.1974 | +0.9 | +0.8 |
| Laredo, Texas | 979.0801 | 979.0806 | 979.0805 | +0.5 | +0.4 |

Note: W10F and 147 are two different Worden gravimeters.

along another north-south line—from the island of Hokkaido, Japan, southward through Australia and New Zealand to McMurdo Sound, Antarctica. Another meridional series of measurements is planned from northern Greenland southward to southern Argentina, and it is hoped to make some supplementary measurements in western Europe and Africa to round out the existing networks in these areas.

In addition, complementary measurements with the Cambridge pendulums have been made in Europe and Africa by B. C. Browne of Cambridge University, and measurements with these instruments are now in progress in South America.

## B. GRAVIMETER PROGRAM

About ten years ago the first practical geodetic-type gravimeter was developed by S. P. Worden of Houston, Texas. This instrument has revolutionized the use of gravity measurements, not only for geodetic studies but also for many regional geophysical studies related to earth structure and geology. It overcame all of the major problems previously restricting long-range gravity connections. The instrument was small, light, rugged enough for field use, had a self-contained power source consisting of small dry-cell batteries, and had a reliable reading time of less than 5 min.

For the first time it was feasible to use commercial air transport for gravity measurements. Without special facilities and arrangements, a gravity reading could be made during the few minutes a plane was on the ground for a routine stop. A closed traverse of as much as 1000 mi could be completed within 12 to 14 hrs and a series of observations extending completely around the world in less than one week.

Although the Worden gravimeter is compensated for changes in temperature, it has an appreciable "drift" rate resulting from slow relaxation of the spring over a period

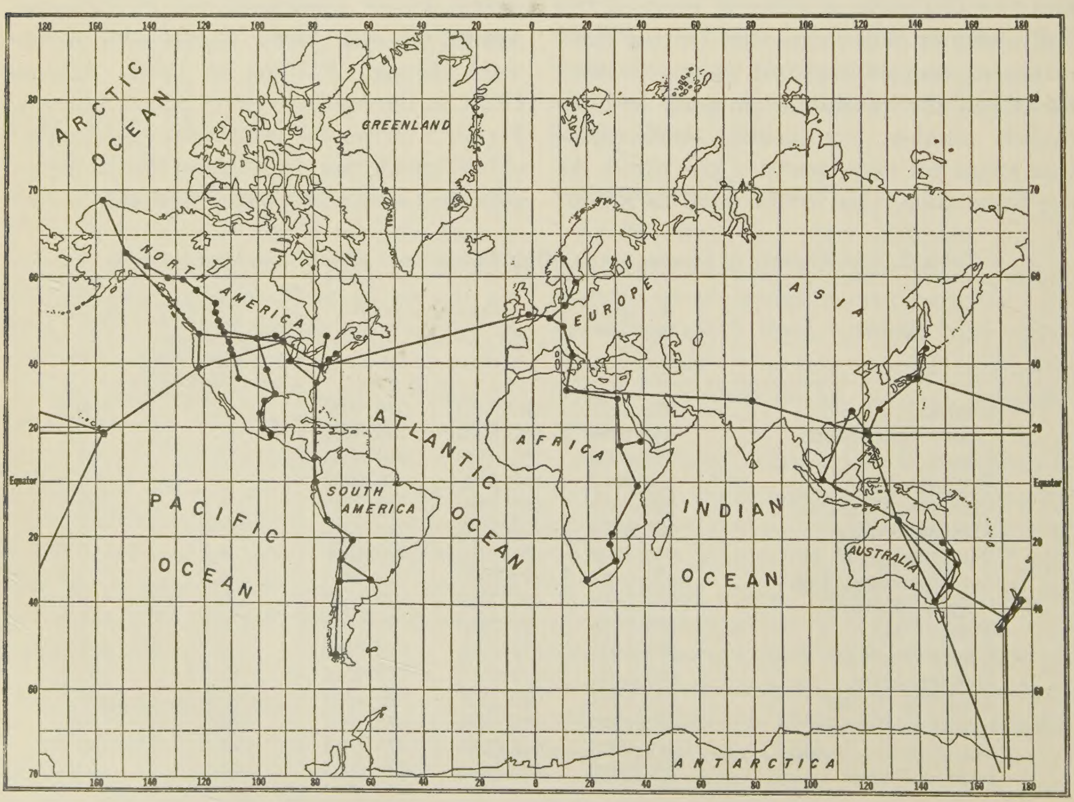


Fig. 2. *World Network of Pendulum Gravity Stations*

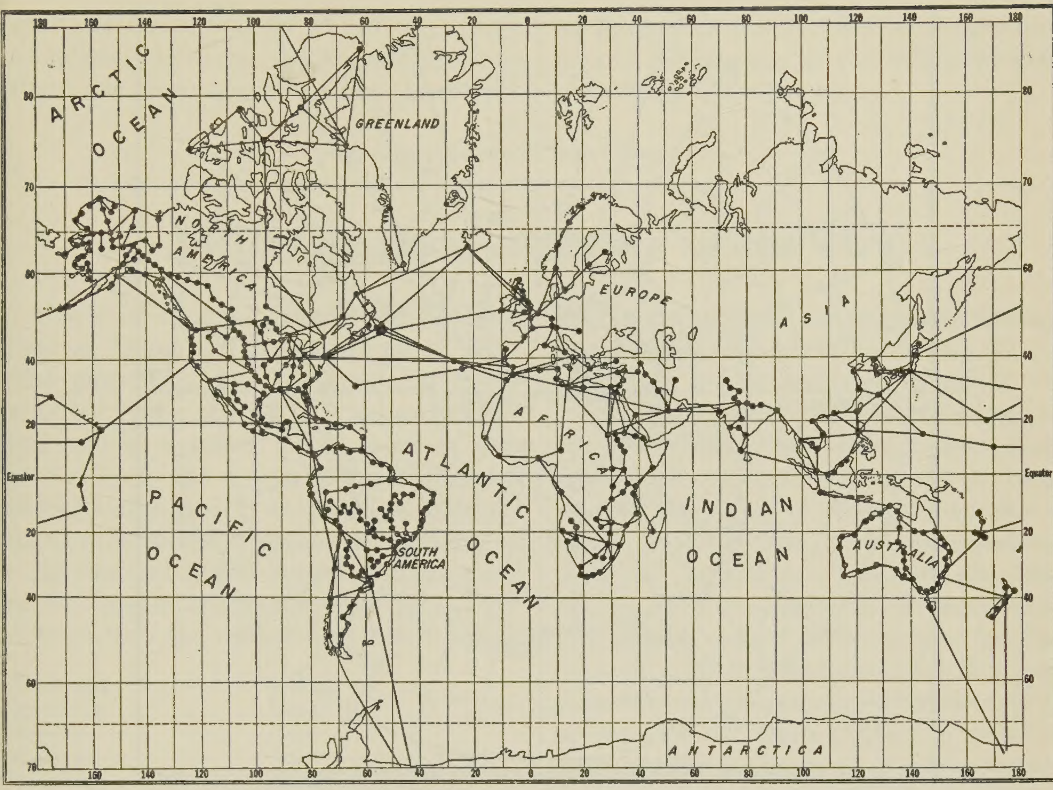


FIG. 3. *World Network of Gravimeter Stations*

of time. However, the speed with which the instrument can be used minimizes this drift effect. On the average, results reliable to 0.3 mgal can be obtained almost anywhere to which air transportation is readily available. The biggest problem in its use is that of calibration. (It was to resolve this problem that the program of gravity standardization measurements using Gulf pendulums was set up.)

How well these problems have been resolved is indicated by the comparison between pendulum gravity values and those for two Worden gravimeters having markedly different scale constants, sensitivity, and range values (Table 2).

**Objectives of Program**

The general objectives of the IGY gravimeter program, as in the pre-IGY period are: (1) to evaluate the accuracy of the various national gravity bases; (2) to integrate the national gravity bases into a unified network; (3) to extend and strengthen the international network of bases; and (4) to build up auxiliary gravity coverage on a regional basis in areas not likely to be investigated in the forseeable future.

Figure 3 shows the locations of the principal gravimeter bases, most of them at airports, throughout the world. Although a total of over 3000 bases have been established in 85 countries, large gaps still exist.

The IGY gravimeter program also includes establishment of base gravity values in Antarctica; traverse measurements in Antarctica; ice floe observations in the Arctic Ocean, with periodic ties to these stations from mainland bases; checking of key stations in the primary world network using the new, precise, "driftless," constant-temperature, LaCoste geodetic gravimeter; and expansion of the overall world net of gravity bases.

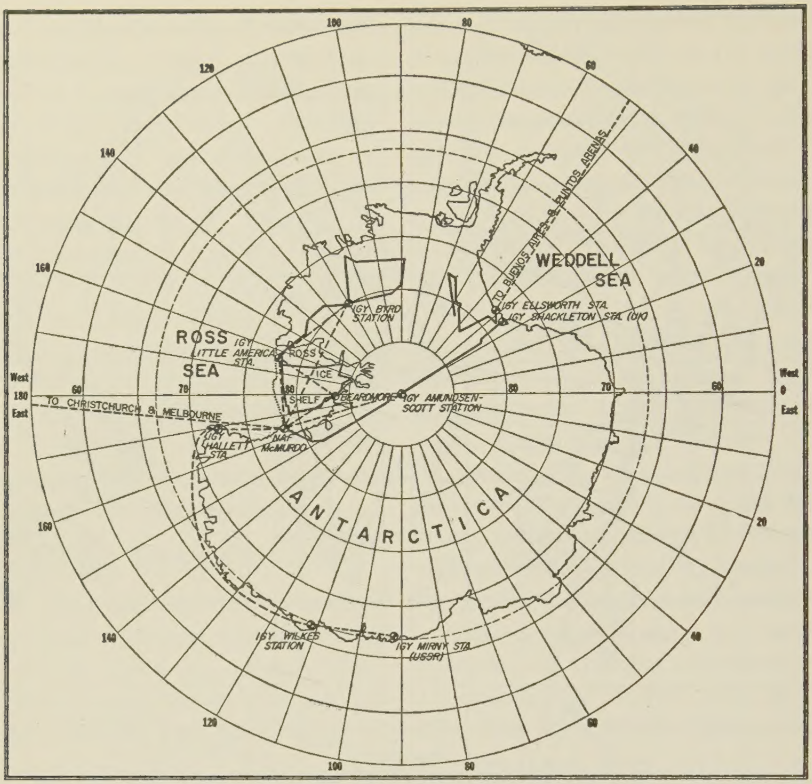


Fig. 4. *Gravity Stations and Lines Along Which US and British Gravity Measurements Have Been Made in Antarctica. Solid lines represent oversnow traverses; dashed lines represent ship or air routes.*

## Antarctic Measurements

Figure 4 shows the locations of IGY gravity bases in Antarctica and routes along which gravity measurements were taken. The route of the British Commonwealth Trans-Antarctic traverse is also indicated since the gravity measurements on this traverse were made on a cooperative basis with an instrument provided by the University of Wisconsin.

Preliminary gravity values for the various Antarctic bases are listed in Table 3. Anomaly values (free-air) for the Byrd Station traverses average ±50 mgals from zero. These small anomalies suggest isostatic equilibrium, in which there is neither an excess nor a deficiency of crustal mass, thus implying crustal stability. The minor fluctuations, however, suggest considerable variation in the thickness of ice, the underlying rock types, or both. (The manner in which traverse gravity measurements have served to supplement the seismic measurements in determining the thickness of the ice cap is discussed in *Bulletin No. 13.*)

Table 3. *Antarctic Gravity Bases*

| | |
|---|---|
| McMurdo | 982.9923 gals |
| Little America | 982.9820 |
| Beardmore | 983.0719 |
| Pole | 982.3290 |
| Marie Byrd | 982.5962 |
| Hallett | 982.7059 |
| Wilkes | 982.4000 (±.002) |
| Mirny | 982.4020 (±.002) |
| Ellsworth | 982.9279 |
| Belgrano | 982.9525 |
| Shackelton | 982.9397 |

## Marine Measurements

One of the more significant phases of the US-IGY Gravity Program is the work being done by the Lamont Geological Laboratory in developing a workable shipboard adaptation of the Graf motion-compensated

gravimeter (see *Bulletin No. 8*). A recently completed run across the Atlantic indicates that this instrument is now essentially operational. It is only a matter of time until gravity information at sea will be as complete as on the continents.

# Fifth General Assembly of the IGY

The Fifth General Assembly of IGY was held in Moscow, July 30–August 9, 1958. The purpose of the Assembly was to review the status of IGY as it approached its end and to consider future needs in geophysics both with respect to the termination of IGY and to fields in which additional international cooperation appeared desirable.

Approximately 365 scientists participated in the Assembly, representing IGY committees from the following 35 countries:

| | |
|---|---|
| Argentina | Ireland |
| Australia | Israel |
| Austria | Italy |
| Belgium | Japan |
| Bulgaria | Mongolian Peoples Republic |
| Burma | Netherlands |
| Canada | New Zealand |
| Chile | Norway |
| Czechoslovakia | Poland |
| Denmark | Rumania |
| Finland | Sweden |
| France | Union of South Africa |
| German Democratic Republic | Union of Soviet Socialist Republics |
| German Federal Republic | United Kingdom |
| Ghana | United States |
| Hungary | Viet Nam Democratic Republic |
| India | Yugoslavia |
| Iran | |

The Assembly was called by the Special Committee for the IGY (CSAGI). As at previous general assemblies, the meeting of CSAGI was characterized by working groups in the various IGY fields: world data centers, world days, meteorology, geomagnetism, aurora and airglow, ionospheric physics, solar activity, cosmic rays, glaciology, oceanography, rockets and satellites, seismology, gravity measurements, nuclear radiation, and publications. The working groups, composed of scientists from the various delegations, met regularly between the opening plenary session on July 30 and the closing plenary session on August 9.

A review of the flow of data to and among the three IGY World Data Centers indicated that satisfactory progress is being made in this aspect of the IGY if account is taken of the routine problems associated with the collection, checking, handling, mailing, and reproduction of basic data. The Assembly urged, however, that the flow be accelerated and recommended that participants make copies available directly to all three World Data Centers in order to speed up the exchange of data and reduce the reproduction burden on the Data Centers. The Assembly requested that, in addition to the raw data, the World Data Centers also collect reprints of published results of IGY programs, and, in view of the value to scientists of these comprehensive collections of data, that the Centers continue in operation for as long as possible.

The single area in which completely satisfactory agreement was not achieved related to rocket and satellite data. With regard to scientific data from rocket and satellite experiments, alternate proposals were made. One advocated that preliminary data be supplied on a routine basis to the World Data Centers in advance of final publication, the other that only final published papers be supplied routinely, with preliminary data furnished only on specific request. A second point of difference was whether size, weight, and other information should be provided on all objects in orbit, including carrier rockets and nose cones, or only on instrumented satellites. Finally, a question arose as to whether precise orbital data

should be supplied or only approximate direction angles for each observing station. The CSAGI has proposed a special committee to consider these three topics, and it is hoped that a satisfactory resolution may be achieved. This would then provide detailed agreement in the rocket and satellite area equivalent to that in the other IGY disciplines.

The Assembly recommended that a World Magnetic Survey be undertaken during the coming period of minimum solar activity. IGY studies provide data during the peak of the sunspot cycle, when the magnetic field undergoes rapid variations. The World Magnetic Survey, however, would provide data on the slow changes of the magnetic field and provide an up-to-date magnetic map. Such surveys are best conducted in magnetically quiet periods, the next of which takes place some four or five years from now. This recommendation will be considered by the International Council of Scientific Unions (ICSU) and by the various members of ICSU, such as our own National Academy of Sciences.

The question of prolonging the IGY for another year was raised by the USSR-IGY Committee. It was decided that the period of intensified geophysical-research effort of the IGY should terminate as planned. However, it was proposed that the coming year be designated "International Geophysical Cooperation-1959" (IGC-1959) and that observational and data-collection activities continue along the general plan of IGY "as far as practicable and at such level and in such fields as may be determined by each participating committee." The resolution has been endorsed by ICSU and its adhering bodies; this will have the following results:

First, it will provide a means for continued interchange of data among countries, and it is planned that data contributed from geophysical research during 1959 would be deposited in the IGY World Data Centers. Second, it will provide a transition period between the present IGY program and subsequent scientific programs in which clear need for further international cooperation arises. The Antarctic and oceanography programs are examples of the latter. ICSU has established special committees for these programs.

The Special Committee on Antarctic Research has already planned a 1959 program for continued efforts by those countries which have been active in the Antarctic during the IGY. A similar committee has been established for oceanography, although the plans for this committee are longer-range. In addition, ICSU will soon consider the establishment of appropriate committees in several other areas, including (i) rocket and satellite research, (ii) solar patrols and alerts, and, perhaps, (iii) the proposed World Magnetic Survey.

Agreement was reached on the publication of processed IGY data and results. A series of volumes, to be published in the *IGY Annals*, will be prepared under the direction of a specialist in each field (the World Reporter). Although complete publication will take several years, the program will afford many advantages: First, economy in publication will be realized through this cooperative, international plan. Second, wide distribution of the IGY results will be possible through a single medium. Third, the long-range burden on World Data Centers should be appreciably reduced by the availability of these volumes of processed data, reports of activities, and research papers.

During the Assembly, a number of special symposia were held. A total of some 200 scientific papers, distributed among the following disciplines, were presented:

Aurora and airglow; cosmic rays; geomagnetism, in a symposium on geomagnetic and ionospheric disturbances; glaciology; ionospheric physics, in symposia on meteors and on the ionosphere; meteorology, in symposia on numerical forecasting, noctilucent clouds, Antarctic meteorology, and

nuclear radiation; oceanography; seismology; rockets and satellites, in symposia on satellite orbits, satellite tracking, atmospheric structure (electrical), atmospheric structure (non-electrical), satellite radio observation, extraterrestrial radiation observations, and miscellaneous; and solar activity.

In addition, at all discipline working-group meetings, reports were presented by participating committees on their programs.

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# Summer Activities—Drifting Station Alpha

*This report is based primarily on material supplied by Norbert Untersteiner, University of Washington, and T. Saunders English, University of Alaska.*

The scientific program at Drifting Station Alpha, one of the two US-IGY stations established on the drifting ice of the Arctic Ocean, has continued almost without interruption despite severe logistic problems.

During the latter part of April, a part of the floe on which the station was built broke off and newly-formed pressure ridges advanced into the camp area. All but ten persons, including both scientific and supporting military personnel—just enough to keep the program serviced—were evacuated. On May 2, the Alaskan Air Command, 11th Air Division, which is responsible for station logistics, decided to move the camp to an adjacent floe about one mile away. The personnel who had been evacuated were returned and removal operations begun.

The task of moving was difficult because of the roughness of the ice surface and the need to jack up all structures in order to place runners beneath them. Moreover, it was necessary to dig power cable out of the ice in order to salvage as much of it as possible.

Because power cable had to be salvaged, spliced, and installed before rawinsonde observations could be made at the new site, two such readings were missed. The IGY seismic, gravity, oceanography, and magnetic programs of Station Alpha, however, continued on schedule. By May 24 the entire camp—consisting of 21 buildings—had been moved and a runway constructed at the new location.

On June 10, two leads (long, narrow water passages in the pack ice) formed across the new runway. Construction of a replacement runway was hampered by the beginning of the melt season, but by continuous draining through core holes it was possible to ready a strip for a C-54 aircraft on June 22. Shortly thereafter, a crack also formed in this runway. From then until late September, when the first landing of the winter season was made, the station was supplied by air-drop.

### Biology

Though not among the disciplines for special IGY study, biological studies were emphasized in the summer program. T. Saunders English of the University of Alaska has been gathering data for an environmental study of the marine life under the floating ice. In addition to instrumental observations of the ice-water environment, the program includes direct observations underneath the ice in "frogman" gear with self-contained breathing equipment.

The amount of light energy in the sea is almost beyond doubt the limiting factor for the photosynthetic process, which is the basis of life in the sea. In the Arctic Ocean, a large portion of the sunlight is blocked off by the floating ice covering 90–95 % of the sea surface. Many hypotheses have been put forth about the extent and variation of solar radiation passing through the ice cover. Direct observation of the transmitted

radiation, by an undersea diver carrying suitable instruments, seems an excellent way to obtain the data necessary to evaluate these hypotheses. Three divers are using submarine photometers with filters to estimate the amount of light available to the plant life growing under the ice.

The underwater program also includes direct observation and sampling of the marine life on the underside of the ice. Previous work has shown that there is a considerable population of diatoms (microscopic plants with siliceous shells) attached to the underside of the ice; that many crustaceans appear to graze on the diatoms; and that seal feed on the crustaceans. Standard sampling equipment fails to give an adequate estimate of the populations involved in this food chain and gives no insight into natural conditions. Direct inspection by an observer under the ice permits description of the plants and animals on the undersurface of the ice, determination of their relationships to one another, and effective sampling for estimates of the populations involved.

It is hoped that these observations will clarify the relationship of this food chain to the unexpectedly large animal population found in high-latitude Arctic waters.

The phytoplankton (plant plankton) studies begun in 1957 were continued and expanded. Standing-crop samples and large-volume samples were taken for identification of plankton. (Standing-crop samples give a quantitative measure of the numbers and kinds of plants; large-volume samples provide a non-quantitative, overall picture of the marine population.) Preliminary analyses of the standing-crop samples showed the expected increase in productivity for the sunny summer months. Complete productivity studies, which can be only partially accomplished at Station Alpha, will include analyses of oxygen consumption and production, carbon-14 accumulation, and chlorophyll abundance. The data obtained will be analyzed to determine daily, seasonal, and depth variations in plankton productivity.

Samples of sea water for chemical analysis were taken at regular intervals. Preliminary analyses for chlorinity, oxygen, phosphates, silicates, nitrates, and nitrites were made at the station. Other samples will be returned to the mainland for more detailed analysis. The microstratification of the upper layers of the water was studied. A thermal probe was used to measure temperature, and the samples of water taken from specific levels were analyzed. The chemical studies and stratification studies should provide data describing the physical environment of the plankton and the nutrients available in the seawater.

In addition to the near-surface studies, horizontal plankton tows were made at various depths to collect foraminifera (microscopic, one-celled, hardshelled animals), and bottom trawls were taken. The bottom trawls have collected two kinds of echinoderms—brittle stars and sea cucumbers—as well as a number of rocks.

**Sea-Ice Physics**

The IGY sea-ice physics and glaciology investigations on Station Alpha (see *Bulletin No. 12*) were accelerated during the summer. Observations of ice accretion and ablation (loss, primarily by melting) were continued at the old site even after the camp was moved. (By September 1 the distance between the new and old sites had increased to two miles.) The 1958 melt season began two weeks earlier than in 1957 and lasted one month longer. Ablation during the 1958 melt season was found to be twice as great as in 1957, but less than accretion during the 1957–1958 winter. Thus, the total thickness of the floe increased during the year.

*Ice Petrography:* Core holes were drilled through the sea ice at regular intervals along lines crossing relatively undisturbed portions of the floe. The cores obtained are analyzed microscopically and chemically; this provides a three-dimensional picture of

the fine structure and the salinity of the ice both along the sampling line and to the bottom of the floe. For selected cores, thin sections of ice from 10-cm intervals were prepared, examined microscopically, and photographed. It was possible to correlate the microscopic structure of the ice with its salt content and also to trace individual layers in the ice for horizontal distances of 10 to 20 m. The layer formed during the past winter, 50 to 70 cm thick, is particularly clear and has been observed in most cores.

*Mechanics of Sea Ice:* On May 14, Andrew Assur and Guenther Frankenstein, of the US Army Snow, Ice and Permafrost Research Establishment, began an intensive study of the strength of sea ice under natural conditions. They measured the tensile and compressive forces needed to break beams of ice cut from the floe; determined salinity and density; measured the electrical resistivity of sea ice; determined the elasticity of sea ice; measured the deformation of ice under load; and surveyed ice conditions in general.

**Underwater Sound**

Charles W. Senior of the Navy Hydrographic Office and E. P. Kelley of the Underwater Sound Laboratory arrived on June 21 to begin a study of long-range, underwater sound transmission between Station Alpha and Station Bravo, almost 400 mi to the south. The latter is on Fletcher's Ice Island, a large piece of shelf-ice thought to have broken off the Ellesmere Ice Shelf. Sound transmission tests were conducted at various depths. Measurements of vertical distribution of ocean temperature and salinity, which affect sound transmission, also were made.

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## IGY Bibliography

"An Interim Bibliography on the International Geophysical Year" has been published by the National Academy of Sciences.

This is the first of a series of bibliographies on the International Geophysical Year to be prepared by the Library of Congress as a joint project of the Library, the Academy, and the National Science Foundation. It is expected that it will be followed by a second interim volume in the spring of 1959 and later by a final complete bibliography listing all references on the IGY of scientific interest collected by the Library of Congress prior to July 1959.

The 64-page publication lists 704 references on the International Geophysical Year published between January 1951 and August 1958. The basis for selection of each entry has been the scientific value, the extent of coverage, historical interest, uniqueness, and to a lesser extent, availability. Titles in Russian, East European languages, and Japanese have been translated into English. The existence of complete translations and English summaries is noted where available.

The Interim Bibliography is priced at $1.00, postage prepaid. Orders should be addressed to the Publications Office, National Academy of Sciences, Washington 25, D. C.

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